Evaluating a Surveillance System

A systematic approach to the evaluation of a surveillance system will facilitate identification of problems and ways to improve the system. The Centers for Disease Control and Prevention (CDC) recommends the following tasks in evaluating surveillance systems:

- **Task A:** Engage stakeholders in the evaluation of the surveillance system.
- **Task B:** Describe the surveillance system.
- **Task C:** Focus the evaluation design.
- **Task D:** Gather evidence on the performance of the system.
- **Task E:** Justify and state conclusions, and make recommendations.
- **Task F:** Ensure dissemination and use of evaluation findings.

Task A: Engage stakeholders in the evaluation of the surveillance system.

Stakeholders are those persons or organizations that help collect data for surveillance of the health event (i.e., disease, injury, or adverse exposure) of interest or use the data for the prevention and control of the health event. Stakeholders can provide input to ensure that the evaluation of a surveillance system addresses appropriate questions, assesses pertinent attributes, and provides information that will be used.

Task B: Describe the surveillance system.

A description of the surveillance system provides the necessary background for the evaluation and includes information about the public health importance of the event under surveillance, the purpose and operation of the surveillance system, and the resources used to operate the system.

Criteria for determining the public health importance of a health event include
- the disease burden
- its potential for spread
- preventability of the disease
- other factors such as public and political perceptions of the health event

The purpose of a surveillance system is the reason the system exists. Its objectives relate to how the data are used for public health action.

The operation of a surveillance system includes a description of the population under surveillance, sources of case reports, when and how sources report cases, and what happens with the data after cases are reported.

Resources used to operate a surveillance system include the costs of personnel, supplies, equipment, travel, training, and services. Resources needed to operate a surveillance system are usually compared with the surveillance system's objectives and usefulness as well as the costs that will result if the system were modified or alternative data sources were developed.

EXAMPLE: Evaluation of the Surveillance of Congenital Malformations in New York State

Task B: Describe the surveillance system.

Importance of the health problem

Congenital malformations, as a group, are relatively common, affecting 3%-5% of live-born children in the United States. They are the leading cause of infant mortality and the fifth leading cause of years of potential life lost among all age groups. Approximately 12% of pediatric hospitalizations are related to congenital malformations. These hospitalizations tend to be longer and more expensive than other pediatric hospitalizations.

Purpose and operation of the surveillance system

Objectives:

- Determine the incidence of congenital malformations.
- Investigate increases in malformations that might be associated with acute toxic exposures.
- Work with other agencies to ensure services and quality care for children with malformations.
- Provide data for planning, advocacy, and education.

Case definition: Any structural, functional, or biochemical abnormality determined genetically or to have been induced during gestation that is diagnosed between birth and 24 months of age in a live-born infant. Abnormalities resulting from the birthing process are not included.

Process: Health care providers (HCP), hospital staff, and genetics laboratories are required to report cases. Reporters submit a case report including a narrative description of the malformation to the state health department (HD) within 10 days of diagnosis. Case reports are reviewed by health department staff and are compared with hospital discharge, birth certificate, and early interventions databases to identify unreported cases or collect additional case information.
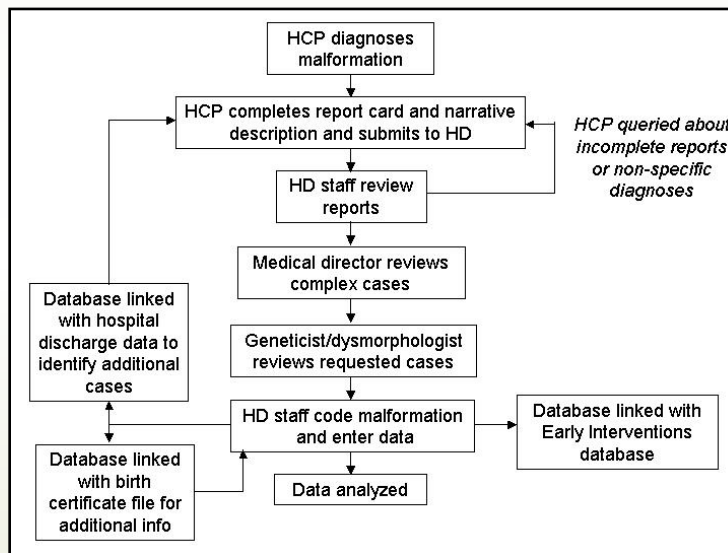
Resources used to operate the surveillance system:

Salaries	$474,250
Program director (1.0 FTE)	
Medical director (1.0 FTE)	
Research scientists (3.0 FTEs)	
Clerks (2.0 FTEs)	
Data entry staff (1.0 FTE)	
Fringe benefits	$140,378
Overhead	$157,775
TOTAL	$772,403

Task C: Focus the evaluation design.

Focusing the evaluation design ensures that time and resources are used efficiently and involves

- determining the specific purpose of the evaluation
- identifying who will receive the findings and recommendations of the evaluation
- considering what will be done with the information generated from the evaluation
- determining standards for assessing the performance of the system

Task D: Gather evidence regarding the performance of the surveillance system.

The performance of a surveillance system can largely be gauged by determining the usefulness of the resulting information and whether system attributes support the objectives of the system.

Usefulness can be assessed by answering the following questions:

- What actions have been taken as a result of information from the surveillance system?
- Who has used the information to make decisions and take actions?
- What other uses might the information have?

Nine basic attributes summarize critical aspects of every surveillance system and reflect the ability of a system to meet its objectives. The attributes are

- simplicity
- flexibility
- data quality
- acceptability
- sensitivity
- predictive value positive
- representativeness
- timeliness
- stability

A balance of the attributes, appropriate to the surveillance system, must be achieved for a surveillance system to meet its objectives within the available resources.

EXAMPLE: Evaluation of the Surveillance of Congenital Malformations in New York State

Task D: Gather evidence regarding the performance of the surveillance system.
Usefulness of surveillance system

Data from the congenital malformations surveillance system has been used to

- disseminate annual reports describing congenital malformations in New York State
- explore associations between clusters of particular birth defects and assumed causes
- track affected children to ensure quality care and enrollment in early intervention programs
- identify cases for epidemiologic studies to determine risk factors for malformations

EXAMPLE: Evaluation of the Surveillance of Congenital Malformations in New York State (continued)

Attributes of the surveillance system

Simplicity: A substantial number of reporters are included in the surveillance system. Matching of congenital malformations data to other databases, such as birth certificate and hospital discharge data, requires special skills among surveillance staff.

Flexibility: Because the majority of congenital malformations are detected through the hospital discharge database and additional case information is obtained from birth certificate data, changing the malformations included in the system or the information collected would be relatively easy.

Data quality: This attribute was not assessed in the evaluation of the New York State congenital malformations surveillance system.

Acceptability: Completing a report of a congenital malformation takes time and might limit the willingness of sources to report.

Sensitivity: The system misses congenital malformations diagnosed among persons aged >24 months, stillbirths, and terminated pregnancies. Among congenital malformations included in the system, studies suggest reporting is 86% complete.

Predictive value positive: Studies indicate that 80%-85% of congenital malformations reported to the system are accurately diagnosed.

Representativeness: Studies suggest the reports are representative, but the system only includes malformations among live-born children and malformations detected by age 24 months.

Timeliness: Linkages between the congenital malformation database and the hospital discharge and birth certificate databases delay the system's timeliness by months.

Stability: Dedicated resources are available through several sources, such as Maternal and Child Health Block Grant, Preventive Health and Health Services Block Grant, and the State Superfund Program.

Task E: Justify and state conclusions, and make recommendations.

We evaluate a surveillance system so that we can draw conclusions about its present state and make recommendations about its future potential. Remember, the attributes, usefulness, and costs of a surveillance system are interdependent. Before recommending changes, consider the interactions among these factors to ensure that the changes do not adversely affect other aspects of the system or incur costs beyond what the system can bear.

Task F: Ensure dissemination and use of evaluation findings.

Deliberate effort is needed to ensure that the findings from a surveillance system evaluation are used and disseminated appropriately. Follow-up might be necessary to remind intended users of their planned uses and to prevent lessons learned from becoming lost or ignored.

Evaluating a surveillance system is not easy. It takes time, requires consultation with multiple persons and agencies, and demands a careful consideration of the attributes and needs of the specific system. To promote the best use of public health resources, however, all public health surveillance systems should be evaluated periodically.

Give it a try with the following exercise.

EXERCISE

Note: This exercise is based on an analysis of the *Salmonella* Typhi surveillance system as it existed in the late 1990s.

Typhoid fever is a life-threatening illness caused by *Salmonella* Typhi. Whereas non-typhoidal salmonellosis usually causes a self-limited diarrheal illness, with animals as a common reservoir, typhoid fever is typically a more severe illness, and humans are the only reservoir.

Approximately 400 cases are reported in the United States each year; approximately 16 million cases (including 600,000 deaths) occur worldwide. About 70% of typhoid fever cases detected in the United States are acquired outside the United States.

Without treatment, the case-fatality rate for typhoid fever ranges from about 10%-20%. With prompt and appropriate antibiotic therapy, case-fatality rates decline to less than 1%. Concern exists regarding emerging multi-drug resistant *Salmonella* Typhi.

Is surveillance of antimicrobial resistance in *Salmonella* Typhi of public health importance in the United States?

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The National Antimicrobial Resistance Monitoring System (NARMS) is a passive, voluntary surveillance system that monitors antimicrobial resistance among enteric bacteria isolated from humans and animals in the United States. The primary objectives of the system are to
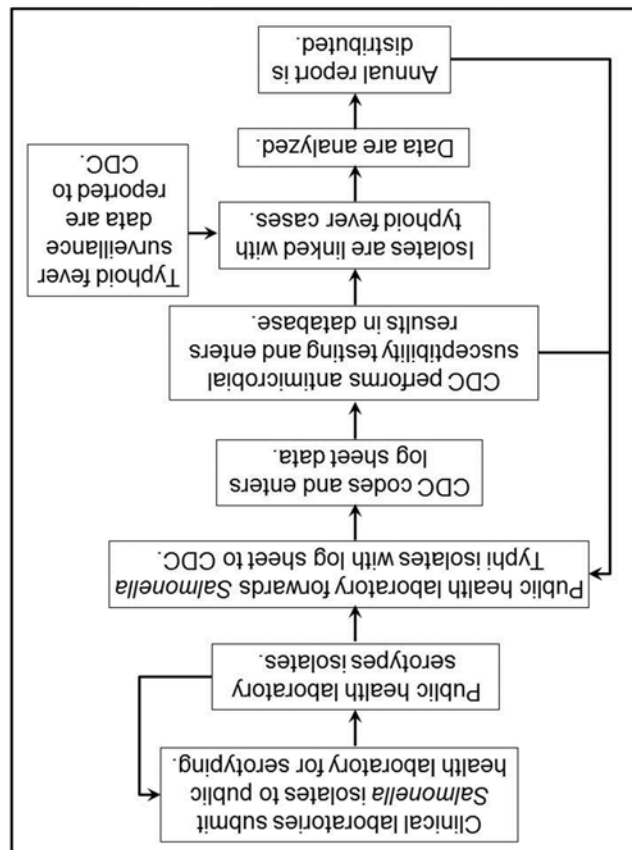
- monitor trends in resistance to antimicrobial drugs critical in human and animal medicine
- characterize risk factors for infection with resistant strains of these bacteria
- provide isolates for research

Public health laboratories routinely serotype isolates of *Salmonella* from clinical laboratories in their state. For NARMS, public health laboratories forward all *Salmonella* Typhi isolates to CDC every 1-3 months. Isolates are accompanied by a log sheet with information about each specimen. Information from the log sheet is coded and entered into a database. Susceptibility testing is performed for a routine panel of antimicrobial agents.

To obtain additional information about the *Salmonella* Typhi isolates, the isolates are linked to reports of typhoid fever that are submitted by state and local health departments to CDC through a separate surveillance system. Some isolates are not matched with a corresponding typhoid fever report and some isolates have duplicate reports. Multiple isolates are submitted for some typhoid fever patients.

Results of antimicrobial susceptibility testing are published annually. Results are shared with public health laboratories but are not provided to the original clinical laboratory or used to direct individual patient treatment decisions.

Diagram the flow of information for the surveillance of antimicrobial resistance of *Salmonella* Typhi through NARMS. Show each step in the receipt and processing of isolates and information.

Answer

Annual report is distributed.

Data are analyzed.

Isolates are linked with typhoid fever cases.

Typhoid fever surveillance data are reported to CDC.

CDC performs antimicrobial susceptibility testing and enters results in database.

CDC codes and enters log sheet data.

Public health laboratory forwards *Salmonella* Typhi isolates with log sheet to CDC.

Public health laboratory serotypes isolates.

Clinical laboratories submit *Salmonella* isolates to public health laboratory for serotyping.

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Attributes of NARMS surveillance for antimicrobial resistance in *Salmonella* Typhi are as follows:

Simplicity: Laboratories provide limited information on the *Salmonella* Typhi specimens by using a log sheet. All specimens and log sheets are submitted to one place at CDC.

Flexibility: Only 50 public health laboratories participate in the surveillance system and only one laboratory at CDC performs antimicrobial susceptibility testing. The small number of participants in the system makes it easy to change system operations.

Data quality: Only a limited amount of data is available on the log sheets. If specimens cannot be matched with patient reports from national typhoid fever surveillance, analysis of antimicrobial susceptibility test results are of limited usefulness.

Acceptability: Efforts required by participating health departments are minimal, and most recognize the usefulness of monitoring emerging antimicrobial resistance.

Sensitivity: The system is passive and relies on voluntary reporting. Only culture-confirmed cases are included. It is likely that many cases of *Salmonella* Typhi infection are missed by this system, but typhoid fever is a severe disease, so it is more likely to be diagnosed than a non-typhoidal *Salmonella* infection.

Predictive value positive: The surveillance system includes culture-confirmed cases only. Trained CDC staff performs all antimicrobial susceptibility testing.

Representativeness: Although laboratory specimens are not collected from all patients with symptoms of typhoid fever, it is a relatively severe disease that is straightforward to detect. However, to the extent that certain kinds of patients, like children or people with a history of recent international travel, are more likely to seek medical care and be tested than others, they might be over-represented in surveillance data.

Timeliness: Isolates are sent to CDC every 1-3 months and are batched until sufficient specimens have been received to justify testing. Results are distributed in annual reports. If an urgent problem is detected, sites can be alerted by telephone.

Stability: NARMS receives dedicated funding at the federal level and is the focus of active collaborations among CDC, the Food and Drug Administration, and the U.S. Department of Agriculture.

Which attributes of NARMS surveillance for antimicrobial resistance of *Salmonella* Typhi are strongest? Which are weakest? How do these relate to the objectives of the surveillance system?

Answer

Strengths: The system is simple, flexible, and acceptable. The predictive value positive is high. The representativeness is unknown but likely to be moderate to high.

Weaknesses: Data quality rests largely on the ability to match specimens with reports from national typhoid fever surveillance. The sensitivity of the system is likely to be low to moderate because of insufficient laboratory testing of cases that occur in the community. The system is not particularly timely as specimens are forwarded to CDC every 1-3 months, specimens are batched at CDC for testing, and results are released on an annual basis.

The low sensitivity and unknown representativeness of isolates have an impact on the system's ability to monitor long-term trends in antimicrobial resistance. Difficulty matching isolates with patient characteristics limits the ability of the system to identify risk factors for infection with resistant strains.

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No estimates are available for the cost of this surveillance system, but the expenditure on *Salmonella* Typhi surveillance is only a fraction of the overall NARMS surveillance system costs. Resources are needed to

- complete the log form and prepare isolates for shipment (state health department)
- ship isolates and test specimens (CDC)
- link susceptibility test results with information from typhoid fever surveillance (CDC)
- enter data into database and analyze and disseminate results (CDC)

Based on the information you have, would you continue surveillance of antimicrobial resistance of *Salmonella* Typhi? If yes, what would you recommend to improve the system?

Answer

Given the known occurrence of antimicrobial resistance in *Salmonella* Typhi and the potential for an increase, continued surveillance is critical. However, the following system changes will make the data more useful:

- Take greater care to eliminate multiple isolates of *Salmonella* Typhi from the same patient.
- Increase efforts to correlate each NARMS isolate with a typhoid fever report so that patient characteristics and risk factors for infection with a resistant strain can be better determined.
- Review NARMS test results frequently to identify emerging trends in antimicrobial resistance and communicate those findings to laboratories and health care providers promptly.
- Educate health care providers on the usefulness of collecting clinical specimens on patients with gastrointestinal illnesses and the usefulness of surveillance information.

Source: Megan E. Reller, CDC Foodborne and Diarrheal Diseases Branch, October 2000.

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